Work Group Performance on Production Operations Management Tasks

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Many organizations are initiating the development of high-involvement and self-directed work teams because they believe that such teams can lead to high productivity, better quality, and a closer focus by workers on what the organization is really supposed to be doing (Wright & Brauchle, 1994). However, the best ways to organize such groups in terms of member characteristics have not yet been conclusively established.

It seems well known that groups often make better decisions than individuals do, even superior individuals. As far back as 1982, Hill stated, "This review has shown that group performance was generally qualitatively and quantitatively superior to the performance of the average individual" (p. 535). Bradshaw and Stasson (1995) indicated that the body of previous research had amply covered how much groups outperform individuals, citing the "assembly bonus effects" of groups. Other studies (Black, Michaelsen, & Watson, 1989; Cohen, 1994; Cooley, 1994; Freeman, 1996; Regan & Rohrbaugh, 1990) have agreed on the efficiency of groups over individuals in various endeavors. Fisek, Berger, and Norman (1991) developed a theoretical model that predicted participation rates in heterogeneous and homogeneous groups. However, research into the *outcomes* of homogeneous versus heterogeneous groups is not nearly so unanimous. Shaw (1976) predicted that "groups composed of members having diverse, relevant abilities perform more effectively than groups composed of members having similar abilities" (p. 235), and some later research does indeed seem to support Shaw's hypothesis. Terwel, Herfs, Mertens, and Perrenet (1994) found that heterogeneous groups were preferable for mathematics tasks. Knupfer (1993) discovered that in learning LOGO language, low-ability students benefited from heterogeneous grouping. Other researchers (Gee, 1992; Goodman & Leyden, 1991; Johnson, 1995; Kelli, Moore, & Tuck, 1994; Savitch & Sterling, 1995; Simsek, 1993; Turpie & Paratore, 1994) have found that heterogeneous groups generate learning or productivity gains, leading them to recommend that groups be heterogeneous in order to facilitate these desirable characteristics. Cragan and Wright (1995) cited Shaw's synthesis of research on the productivity of heterogeneous and homogeneous groups by stating of heterogeneous groups, "the rich and diverse backgrounds of their members make them potentially more capable of solving group problems than are homogeneous groups" (p. 142).

Other researchers (Gnagey & Ostrowski, 1992; Stephenson, 1994) have not concurred. Their research has indicated that heterogeneous groups do not necessarily lead to higher achievement or productivity.

While the weight of research seems to strongly suggest that in most cases the work outcomes of heterogeneous groups are of higher quality than outcomes for homogeneous groups, the question of which group performs better and under what circumstances has not yet been conclusively answered. In the wake of such inconclusive research results, this study focused on the quality differences in outcomes of a production and operations management (POM) project developed by the two types of work groups in a university setting.

QUESTIONS

Consequently, we sought answers to the following research questions:

- What are the productivity differences between heterogeneous work groups that have been randomly assigned and homogeneous work groups that were self-selected on POM tasks in higher education?
- What are the differences in peer evaluation scores for heterogeneous and homogeneous groups on a POM task in higher education?
- What are the differences in final scores as adjusted by peer ratings for heterogeneous and homogeneous groups on the POM task?

SEEKING ANSWERS

We investigated the effect of work group type—heterogeneous versus homogeneous—on group productivity in a production operations task. In a learning setting, heterogeneous groups have been described as groups that are purposefully constituted by random assignment in order to achieve a diverse group membership (Watson & Marshall, 1995) whereas traditional groups are usually self-selected by the group members and are generally thought to be homogeneous (Hooper & Hannafin, 1991; Johnson & Johnson, 1984). These types of assignment were used in the study. Because the students were in baccalaureate technology programs and planned on going into industry after graduation, we believed that their behavior on the POM task

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would model the effects that might occur outside an academic setting and that these effects could demonstrate appropriate group assignment methods that had the potential to benefit business and industry.

For this study the Managing Industrial Operations class, a junior-senior level course offered by the Industrial Technology Department at Illinois State University, was chosen. It is a required course for all industrial technology majors. Twenty-five students were enrolled in this particular course during the first semester in which the study was conducted, and 51 students were enrolled during the second semester. The same instructor taught both classes and used the same textbook, syllabus, and materials.

After gaining written consent from the participants, each class was divided in half by means of a lottery drawing. One-half of the class was moved to a different room to facilitate group formation. The first group was instructed to further divide themselves into groups of four by mutual agreement or self-selection. These groups were termed *homogeneous* due to the belief that individuals with similar backgrounds will choose to work together. The other half of the class was subdivided by lottery into groups of four with no input from the individuals. This set of groups was termed *heterogeneous* because randomization of the selection process should yield groups whose members have diverse backgrounds and skill sets.

The instructor was blind to the selection process in both classes to prevent bias in grading the group assignment and did not know which students were assigned to which groups until after final grades had been assigned. The graduate assistant who completed the selection process had no influence on the grades of the groups. The groups were instructed to select a company to analyze in terms of POM characteristics. The group grade was based on a written report according to previously established criteria. The grade for the written report was the raw score of the report as modified by group assessment of the contribution of each individual. For the purpose of this research, the raw scores on the written report, the peer evaluations, and the adjusted grades were analyzed.

The group project was to examine an industry that had POM components for the purpose of assessing current organizational structure, management systems, human resources, production and operation methods, planning and scheduling systems, and quality and production issues. Each group was provided with information on industries in the local area from the Chamber of Commerce and the Harris Industrial Guide. The groups were instructed to contact the plant manager or production manager, vice president, or chief executive officer of the company of their choice. After approval by the instructor, each group wrote a letter to the company soliciting its participation in the project. In the letter, the company was assured that information released to the students was for educational purposes only and would not be made available to the public. The letter was copied to the instructor for reference purposes.

Students completed the assignment according to a carefully controlled format that included a description of each heading and the kind of information contained therein. They were also provided in the syllabus with a copy of the evaluation sheet that was used to grade their group reports. The evaluation sheet included each section to be included in the report and the number of points possible for that section. The instructor graded the group projects according to the evaluation sheet.

After all work was completed in the course, the students evaluated each other by means of a round-robin peer evaluation. Each student evaluated the contribution of each of the other group members on a 1 to 5 scale, with 5 indicating adequate and appropriate contribution to the project and 1 indicating little or no contribution to the project. Attached to each peer evaluation sheet was a group assignment sheet that indicated the assignments each team member was given by the group and the results of those assignments (e.g., “turned in Section 2 on time”). The group assignment sheet was maintained by the team leader. Team members indicated their acceptance of assignments by placing their initials next to the assignment statement on the group assignment sheet. The assignment sheet was distributed during the peer evaluation to guard against bias in the evaluation process. Students were instructed that group members who did everything they were supposed to do on the project (that is, those who completed all assignments to which they affixed their initials on the group assignment sheet) should receive a rating of 5. The ratings were averaged over each group for each student and the average divided by 4 to obtain a percentage. The percentage was then multiplied by the value of the group project to obtain the grade of the individual student on the project. If a project was worth 142 out of 150 points and the average peer evaluation for a particular student was 4.5, the peers were saying that this particular student contributed 90% of what he or she was expected to and was therefore entitled to 90% of the value of the project to which he or she contributed. The adjusted grade of the student on the project would be 127.8 points.

After the instructor graded the group projects, information about group formation was revealed to him. Group performance data were subjected to statistical analysis to establish whether heterogeneous group performance significantly differed from homogeneous group performance on this task and whether peer evaluation scores and final project scores differed by type of group to which students belonged.

WHAT WE LEARNED

The data were placed in a Microsoft Excel file, converted into an SPSS file, and subjected to statistical analysis using SPSS 7.5 for Windows. The question investigated was: What are the productivity differences between heterogeneous work groups that were randomly selected and homogeneous work groups that were self-selected on POM tasks in higher education?

In order to respond to this question, we ascertained whether the groups differed in terms of (a) raw scores on the project, (b) peer evaluations of the contributions made by the individual members to the project, or (c) weighted scores on the project after peer ratings were used to adjust the raw scores. The raw project scores indicated the absolute value of the projects as rated by the instructor. Peer evaluation scores, on a scale of 1 to 5, indicated the average peer rating of each individual's contribution to the project as viewed by other team members. This value was separately analyzed because it is well known that group efforts require the cooperation and help of all members to achieve an outcome, and it is reasonable to expect that the quality of the product is strongly affected by the contributions of all members. The weighted scores indicated the final values of the projects for individuals after being weighted by peer evaluations.

Descriptive statistics were calculated for the average score, by group, for raw scores on the project, peer evaluations, and adjusted project scores. Each score was then statistically analyzed to ascertain whether self-selected (homogeneous) or randomly selected (heterogeneous) groups performed differently on that measure.

Raw Project Scores

Descriptive statistics for raw project scores of the two types of groups are shown in Table 1 below. On average it appeared that the randomly selected groups obtained slightly better scores than did the self-selected groups.

The difference of 3.87 points in favor of the heterogeneous groups may not seem very great; however, many students would probably state that, other things being equal, they would prefer that they were assigned to one of the heterogeneous groups because they would be more likely to receive a higher grade. Although the difference seemed to have some practical significance to students, we wanted to know if it was also significant in a statistical sense.

The raw score data were therefore subjected to an independent *t* test to ascertain whether the difference in favor of the heterogeneous groups was statistically significant. Because the research suggested that heterogeneous groups may perform better, a directional hypothesis was used. Levene's test for equality of variances revealed that the group variances were not significantly different (F = .011, p = .918); therefore, equal variances were assumed. The results of the analysis are depicted in Table 2.

The raw score difference in favor of the heterogeneous groups was not found to be significant.

Table 1
Descriptive Statistics for Homogeneous and Heterogeneous Group Raw Score Performance on the POM Project

Type of Group	*N*	Mean	Std. Deviation	Std. Error
Homogeneous	35	127.0346	10.4044	1.7587
Heterogeneous	36	130.9064	11.8165	1.9694

Table 2
t Test for Equality of Means for Homogeneous and Heterogeneous Group Raw Score Performance on the POM Project

t	*df*	Sig. (1-tailed)	$\mu 1 - \mu 2$	Std. Error Difference
1.164	69	.074	3.8718	2.107

Peer Ratings

Average peer ratings for students in the homogeneous and heterogeneous groups were treated to the same statistical analysis. Descriptive statistics for the peer ratings—the round-robin ratings of group members concerning the performance and contribution of each group member—are depicted in Table 3.

These results indicate that the heterogeneous group enjoyed a 26.6% advantage in peer ratings, which seemed substantial and suggested that the difference may be statistically significant.

Independent *t*-test analysis for peer ratings was conducted, assuming that the variances were *not* equal as indicated by Levene's test (F = 4.541, Sig. = .037), and yielded the results shown in Table 4.

Clearly, these results indicate that students in heterogeneous groups had significantly higher peer ratings than did those in homogeneous groups. Since the peer ratings influenced the students' grades for the entire project, the adjusted scores were investigated next.

Adjusted Scores

Students' adjusted scores—the raw scores adjusted by the peer rating—were investigated across the groups. The descriptive statistics in Table 5 show a considerable point value advantage for the heterogeneous groups on peer rating scores.

When adjusted scores were compared, there was a 12.81 point advantage in favor of peer ratings for students in the heterogeneous groups over those in the homogeneous groups. This difference was subjected to statistical analysis to identify its degree of significance.

An independent *t* test of score differences between homogeneous and heterogeneous groups yielded the results given in Table 6. Equal variances were assumed, as indicated by Levene's test (F= .154, Sig. = .696).

The adjusted scores for heterogeneous

Table 3

Descriptive Statistics for Homogeneous and Heterogeneous Group Peer Ratings on the POM Project

Type of Group	*N*	Mean	Std. Deviation	Std. Error
Homogeneous	35	4.0486	1.0129	0.1712
Heterogeneous	36	4.5183	0.7921	0.1320

Table 4

t Test for Equality of Means for Homogeneous and Heterogeneous Group Peer Ratings on the POM Project

t	*df*	Sig. (1-tailed)	$\mu 1 - \mu 2$	Std. Error Difference
2.173	69	.0165*	0.4698	0.0392

* Indicates statistically significant difference.

Table 5

Descriptive Statistics for Homogeneous and Heterogeneous Adjusted Scores on the POM Project

Type of Group	*N*	Mean	Std. Deviation	Std. Error
Homogeneous	35	102.0092	28.6052	4.8352
Heterogeneous	36	114.8227	29.9873	4.8312

Table 6

Test for Equality of Means for Homogeneous and Heterogeneous Group Adjusted Scores on the POM Project

t	*df*	Sig. (1-tailed)	$\mu 1 - \mu 2$	Std. Error Difference
l.874	69	.0325*	12.8135	0.004

* Indicates statistically significant difference.

groups were significantly higher than those for homogeneous groups. The advantage of 12.81 points for the heterogeneous group indicated that, on average, students from one of these groups could be expected to score 11.2% higher than students from homogeneous (or self-selected) groups.

WHAT IT MEANS

Previous research has indicated that heterogeneous groups may perform better on group tasks in terms of the quality and quantity of their results when the tasks require application to new materials, processes, and issues and that homogeneous groups may perform better on day-to-day maintenance tasks. However, previous studies were not unanimous about the superiority, or the nature of the superiority, of heterogeneous work groups over homogeneous ones.

We found that when junior- and senior-level students were randomly divided into two groups and one of these groups formed self-selected work teams while the other was randomly assigned to work teams, there were some outcome differences in favor of the randomly assigned work groups. Statistically significant differences were present for peer evaluations and adjusted scores received by students but not for raw scores on the POM projects. The size of the difference was most striking for the peer evaluations. We found that there was a statistically significant advantage (26.6%) in peer ratings for heterogeneous groups over the homogeneous groups. When individual scores were adjusted to account for peer ratings, students in the heterogeneous groups still maintained an overall advantage of 11.2% and an average point gain of 12.81 points.

From our experience—and we suspect the same is true for others—when given a choice of group formation, most students favor self-selected groups, even though the research suggests that randomly selected groups have better product outcomes and therefore may receive better grades. What is not clear is whether the students would continue to register such preferences in the face of the results of this study, which show meaningful point gains on this particular project for the randomly selected groups.

The reasons for the results of this study are also not yet clear. We are not certain why such a large difference in peer ratings occurred. Do individuals feel so comfortable in the presence of their friends in a self-selected group that they fail to put forth the level of effort that they would if they were working with a group of people they do not know well? Is there more synergy with the heterogeneous groups? Cragan and Wright (1995) cited four major outcomes for evaluating task groups: productivity, quality of work, consensus, and member satisfaction. In this study, the quality of work, in terms of statistical analysis, was no different for the two kinds of groups. But then, how were the member contributions seen so differently by the members of the two different types of groups? Is it possible that students in homogeneous groups felt they knew the capabilities of their friends and were more likely to be critical of their work, but those in heterogeneous groups gave “strangers” the benefit of the doubt? What about the other three outcomes? Could productivity, consensus, and member satisfaction have differed for these groups and affected the group members’ ratings of their peers? Would the same results be obtained if this study were replicated in an industrial setting? It seems certain that further study of these issues will provide information useful to both education and industry.

These results may assist industrial technology educators in determining how to form groups so that the best student products result. More important, previous research has indicated that the productivity of groups depends to a large extent upon the quality of member interaction and satisfaction. This study supports a difference in peer evaluation of group members. It *implies* that selection of work teams *outside* of an academic setting (e.g., in industry) *may* display similar effects and therefore may benefit from similar procedures in group assignment.

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